

CHAPTER VII. SUMMARY AND CONCLUSIONS

Summary of Findings

Continuing growth in the popularity of nature-based recreation and tourism in protected natural areas will undoubtedly carry the problem of recreation resource impacts and its threats to the quality of natural environments and recreation experiences into the next millennium. Managers and researchers will continue to be challenged to develop reliable methods for assessing and evaluating recreation resource impacts, and to formulate effective and efficient actions to constrain the magnitude of impacts within acceptable limits. Evaluations of the overall magnitude of impacts will still need to be based on two constituent components: the severity and spatial qualities of impacts.

The goal of this dissertation was to expand our understanding of the spatial dimension of recreation resource impacts and their assessment and evaluation. A thorough literature review on recreation ecology and recreation resource management revealed that although the importance of spatial knowledge of recreation resource impact are generally recognized, investigations devoted to assessing and evaluating spatial qualities of recreation resource impacts are scarce. In order to fill some of the knowledge gaps, this dissertation set out to examine three specific spatial issues: (1) the characterization of impact and spatial patterns, (2) the determination of spatial sampling strategies, and (3) the quantification of spatial

qualities using indices. Results of these examinations were reported as three separate papers (Chapters IV, V and VI).

Two empirical data sets were collected from a comprehensive recreation impact assessment and monitoring project in Great Smoky Mountains National Park. The project was composed of two parkwide impact assessment surveys: (1) an assessment of all official and unofficial campsites in the park using a combined condition-class and multi-indicator survey design, and (2) an assessment of 35% of the park's backcountry trail system (72 trails) using a census-based survey design. These two data sets provided the basis for the analyses involved in this dissertation.

The purpose of the first paper was to improve our understanding of the dimensional structure and spatial patterns of backcountry camping impacts by means of multivariate analyses and mapping. Factor analysis of 195 established campsites on eight impact indicators revealed three dimensions of camping impact: land disturbance, soil and groundcover damage, and tree-related damage. Cluster analysis on factor scores yielded three distinctive campsite types (clusters) that characterize both the intensity and areal extent of impacts. Spatial patterns and site attributes of these three campsite types and an additional group of primitive campsites were illustrated and discussed. The impact dimensions and typology developed in this study demonstrate that backcountry camping impacts can be viewed holistically with the aid of multivariate and mapping techniques.

The purpose of the second paper was to examine the influence of sampling interval on the accuracy of selected trail impact indicator estimates for the widely applied systematic point

sampling method. A resampling-simulation method was developed and applied. The trail assessment data set was assigned as the 'ground truth' data set to compare against a series of computer-simulated point data sets extracted to represent increasing sampling intervals. Results show that using systematic point sampling for estimating the lineal extent of trail impact problems can achieve an excellent level of accuracy (around 10% accuracy loss) for most impact types examined at sampling intervals of less than 100 m, and a reasonably good level of accuracy (around 50% accuracy loss) at intervals between 100 and 500 m. The magnitude of accuracy loss values were higher when the directions of accuracy loss (underestimate vs. overestimate) were not considered. The choice of sampling interval appeared to have greater influence on the resulting estimate accuracy when shorter intervals are under consideration. Responses of accuracy loss on lineal extent estimates to increasing sampling intervals varied across different impact types, while responses for frequency of occurrence estimates were consistent, approximating an inversely asymptotic curve. Results of stepwise regression analyses showed weak relationships between accuracy loss of lineal extent estimates and environmental and impact characteristics, but strong positive relationships between accuracy loss of occurrence estimates and mean problem segment (or impact incident) length.

The purpose of the third paper was to expand the scope of indices used for evaluating recreation resource impacts. Two specific objectives were to review and synthesize the recreation ecology and recreation resource management literature regarding use of spatially explicit indicators and indices, and to propose and apply selected spatial indices that are

mostly lacking in the literature to empirical impact data sets. The literature review revealed that previous use of spatial indicators and indices was limited in scope and diversity. Three spatial indices primarily adapted from the geography and ecology literature were proposed for quantifying spatial distribution and association patterns, the two aspects most lacking in the existing recreation impact literature. Each of the proposed indices was applied to the trail assessment data set. Results show that the Lorenz curve and associated Gini coefficient, and linear nearest-neighbor analysis and associated LR ratio were effective in quantifying the spatial distribution patterns of trail impacts at landscape and trail scales, respectively. The use of Lorenz curves and Gini coefficients, for instance, revealed uneven distribution patterns of three impact problems, excessive trail widths, exposed roots, and wet soil, among the surveyed trails. The application of linear nearest neighbor analysis and LR ratios also illustrated varying spatial distribution patterns of tread incision and wet soil along a trail route. The performance of the impact association index in revealing spatial association patterns was less promising, requiring further analysis and refinements.

Management Implications

Several major management implications were identified based on the research findings. In general, this dissertation has demonstrated: (1) the value of recreation impact assessment and monitoring programs in providing data for examining not only the severity, but also the spatial qualities of recreation impacts, and (2) the utility of spatial analytical approaches in understanding recreation resource impacts and their assessment and evaluation.

The campsite impact dimensions and typology found in Chapter IV, for example, suggest that backcountry campsite management strategies could be targeted to specific campsite types in order to address common impact problems or relationships to shared influential factors. The dimensional structure of campsite impacts, if shown to be stable, can be used to streamline field assessments by selecting in each impact dimension representative indicators that possess higher levels of measurement or estimate accuracy and precision. Field time may then be reduced or utilized for measuring indicators that represent other impact dimensions, assessing more campsites, or collecting a more comprehensive data on all campsites.

The findings of the second paper (Chapter V) suggest that systematic point sampling is an effective trail impact assessment method for estimating the lineal extent of impact problems. Specific guidelines for selecting a sampling interval are provided based on the simulation results. Sampling intervals less than 100 m and 500 m are likely to yield very accurate and reasonably accurate lineal extent estimates of major impact problems, respectively. On the other hand, systematic point sampling was found to be an inaccurate method for estimating frequency of occurrence of impact problems, unless sampling intervals were set at unrealistically fine levels, or minimal observation unit size defining an impact occurrence was unusually large.

The above guidelines, however, should be viewed with caution when applying to other locations with different environmental, use, and impact conditions. Further investigations should be conducted to determine the generalizability of the present findings. Nevertheless,

the resampling-simulation method developed in this study can be replicated in such investigations. A census-based problem assessment, coupled with a follow-up analysis using the method illustrated in this study, can be a valuable first step in establishing long-term trail IA&M programs, in which an optimal sampling interval range with acceptable accuracy is determined before investing efforts in data collection.

The application of three proposed spatial indices in the third paper (Chapter VI) demonstrate their utility in quantifying the spatial distribution patterns of trail impacts. Applying these spatial indices in park and recreation resource management is recommended to supplement indicators and indices that reflect the severity of impacts. Potential adoption of these and other spatial indices in management planning frameworks, such as Limits of Acceptable Change (LAC) and Visitor Experience and Resource Protection (VERP), should also be considered.

The use and communication of the proposed spatial indices can also inform managers in making their resource management and maintenance decisions. At the trail level, for example, low LR ratio values of an impact type reflect high levels of clustering of that problem at a few locations along a trail corridor. An increasing LR ratio values over time, on the other hand, could indicate a trend of proliferation of that problem in space. At the park or landscape level, high Gini coefficients of an impact type in a park reflect a high degree of spatial concentration (or distributional inequality) of that problem on a few trails, where trail closure and reroute could be more effective solution. Finally, high impact association index

values may be indicative of substantial coexistence of two or more impact types at "problem" spots, at which top maintenance priority should be placed.

Study Limitations

Recreation ecology studies have been criticized as being mostly after-the-fact designs which are limited in their ability to evaluate causal relationships and to disentangle environmental factors from human recreation influence (Wall and Wright 1977, Cole 1987). The present study inevitably suffers from this limitation. However, limited funding and management orientations towards applied research limit use of experimental research approaches for assessing recreation resource impacts. Recreation resource managers require a scientifically valid yet efficient methodology for impact assessment and monitoring that provides managerially relevant data for evaluating the magnitude of recreation resource impacts. The purpose of this dissertation, and the recreation impact assessment project on which this dissertation was based, was to advance such efforts.

The impact indicators and indices in this project and dissertation were selected and developed with their management utility in mind. An obvious trade-off in this process is the diversity and details of measurement. For instance, only lineal extent of impacts was recorded on the surveyed trails, with no measurements on the degree of muddiness or actual depth of trail treads. While levels of soil erosion and excessive width were rated at an ordinal scale, these levels were combined to expedite analyses and to increase sample sizes for each impact type.

The subjects of this dissertation were limited to trails and campsites, two primary locations of recreation resource impact. Other locations or habitats, such as day-use recreation sites, frontcountry trails and campgrounds, were not examined. Impact patterns at these locations are likely to be different. Results and implications of this study should not be extrapolated to frontcountry situations.

As noted in Chapter IV, some primitive campsites, many of which are unofficial, were omitted from the multivariate analyses due to their incomplete data sets. During the design phase of the GSMNP recreation impact assessment project it was decided that field time could be most efficiently spent if the number of indicators assessed was commensurate with degree of campsite impact. Management interest in low impact sites (those lacking exposed soil) was limited to their number and location so fewer impact indicators were assessed. However, lack of information on some impact indicators for these low-impact sites limited a more complete examination of campsite impact patterns.

Trails included in this study were not selected at random, implying that there are possibilities of selection bias involved. In addition, only the lineal extent of trail impact problems were documented. Measures of impact intensity were limited to an ordinal scale, such as various levels of soil erosion and trail widths.

The influence of amount of use on the spatial qualities of recreation resource impact could not be tested. Like many other recreation impact assessment studies, information on amount and type of use was largely unavailable. Accurate trail and campsite use data,

particularly spatial patterns of visitation, would likely contribute to the understanding and explanation of the spatial patterns and variabilities of recreation impacts.

Inter-rater precision is a concern in recreation impact assessment. High inter-rater variability would limit the validity of the dissertation findings. This issue has been examined by Cole (1989a) and recently by Williams and Marion (1995). Examination of this issue was beyond the scope of this study. Identification of the sources, causes, and the extent of inter-rater variability are needed.

Finally, the results and implications of this dissertation were developed from only two GSMNP data sets. The limited scope and peculiarities of the data must be recognized before applying these findings and recommendations to other environmental and recreational settings.

Future Directions of Research

This dissertation has examined analytical and methodological issues associated with assessing and evaluating recreation resource impacts. It should be viewed as a first step toward improving the spatial understanding of impacts. A great need still exists for recreation researchers in general, and recreation ecologists in particular, to incorporate spatial elements in their investigations. Spatial issues examined in this study, as well as the underexplored spatial questions discussed in Chapter II, seem to be a good place to start.

Several specific suggestions for future research can be made in light of the research results. Most of these suggestions are related to the generalizability of the present findings. First, the stability of the dimensional structure and typology of camping impacts identified in

the first paper (Chapter IV) needs to be verified using similar survey procedures in different national parks or equivalent protected areas.

Second, the influence of sampling interval on the accuracy of lineal extent and occurrence estimates was examined in the second paper (Chapter V) by means of a resampling-simulation method. This method, or its refinement, should be used to examine trails in other environments such as arid regions. Results from other areas can be compared with the present study to determine if there is consistency in response patterns of accuracy to changing sampling intervals for the same or different impact problems. Examinations should also be conducted on the influence of sampling interval on the accuracy of estimating trail "conditions" (e.g., trail width) and impact "severity". Results from these studies will provide a more complete evaluation of the influence of sampling interval.

Third, the review of literature and the two-dimensional matrix (Table 6.1) on the use of spatial indices in the third paper (Chapter VI) can be utilized as a framework for evaluating knowledge gaps in current research. Application of the three spatial indices proposed may be extended to different data in point, line, and areal forms. In particular, the Impact Association Index should be further refined. Alternative indices for quantifying spatial distribution and association of recreation impacts are needed (please refer to Appendix V for some additional examples). Further studies are also called for to examine the ecological and social importance, as well as management utility of these and other spatial indices in recreation impact evaluation. Results should be communicated among researchers and to managers. To expedite the application of spatial indices in management planning and decision-making,

calculations of these indices should be written into algorithms and incorporated as applications or macros in commercial computer software packages.

Effective spatial analysis of recreation impacts is hinged on the quality and type of data. In order to facilitate a spatial focus in recreation ecology research, spatial data need to be incorporated in impact assessment surveys or collected from ancillary sources such as maps and digital databases.

Conclusion

The development of recreation ecology has been largely a response to the management problem of recreation resource impacts (Cole 1989b, Kuss et al. 1990, Liddle 1997). The magnitude and consequences of this problem warrants a field of study in which systematic investigations are conducted, knowledge is accumulated, and research results inform and guide management efforts.

Previous recreation ecology studies have largely been approached from biological and ecological perspectives, likely due to the training of investigators. These research emphases have made important contributions to our understanding of recreation resource impacts and to the advancements and standardization in research methodology (Kuss 1986, Cole and Bayfield 1993). However, as Goldsmith (1985:162) stated, "the problems [of recreation resource impacts] are somewhat broader than those usually encountered by ecologists and inevitably lead them to consider subjects as diverse as human characteristics and land management". It is hoped that this dissertation would be a part of the process of expanding the scope of

recreation ecology to include a spatial focus, the value of which has been clearly demonstrated by geographers (National Research Council 1997).